# REMARKS

Claims 1-59 remain pending in the present application.

Claims 1-59 have been rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 6,380,056 to Shue in view of U.S. Patent No. 6,207,589 to Ma. This rejection is respectfully traversed, for the reasons presented below.

A) <u>Neither Shue nor Ma discloses forming an oxidation layer over a dielectric layer or silicon Nitride layer as recited in independent claims 1 and 40.</u>

1) *Applicants' Claimed Invention*

Claim 1 is directed to a method of forming a capacitor comprising a substrate, a first conductive layer, a dielectric layer, an oxidation layer, and a second conductive layer. Similarly, performance of the method recited in independent claim 40 forms a structure comprising a substrate, a conductive layer, a silicon nitride layer and an oxidation layer. In the structure formed by the method recited in both of these independent claims, an oxidation layer is formed as a separate and distinct layer from the dielectric or silicon nitride layer beneath it.

2) *The Shue reference*

In contrast to the claimed invention, the structure formed by the method disclosed in Shue does not include an oxidation layer formed over a dielectric layer or silicon nitride layer. Rather, the oxidation layer formed in Shue completely consumes the silicon nitride layer, so that the resulting structure lacks a silicon nitride/dielectric layer under the oxide layer as claimed in the present application.

To form this structure, Shue discloses first forming a silicon layer 12 on a substrate 10 (Fig. 1). The silicon layer 12 is then annealed in a nitrogen-containing atmosphere in which oxidizing materials and reducing materials are specifically excluded, to form a silicon

nitride containing layer 14, as shown in Fig. 2 and discussed at column 6, lines 43-62. The silicon nitride layer formed in this manner is very thin, about 1 to about 20 angstroms. (Shue, col. 7, lns. 3-5). During formation of the silicon nitride containing layer 14, the silicon layer 12 is partially consumed, and becomes the partially consumed silicon layer 12' shown in Fig. 2.

Next, Shue discloses annealing the substrate 10, the partially consumed silicon layer 12', and the silicon nitride containing layer 14 in an oxidizing atmosphere to transform silicon nitride layer 12' <u>entirely</u> into a thermally oxidized silicon nitride containing layer 18, as shown in Fig. 3. In other words, the <u>entire thickness</u> of the silicon nitride containing layer 14 of Fig. 2 becomes the oxidation layer 18. (Shue, col. 7, lns. 25-33). Furthermore, the oxidation process even reaches beyond the silicon nitride containing layer 14 to further consume the already partially consumed silicon layer 12', thus transforming partially consumed silicon layer 12' into a further consumed silicon layer 12''. (Shue, Fig. 3, col. 7, lns. 28-30). Thus, after exposure of the structure to the oxidizing atmosphere, silicon nitride layer 14 ceases to exist, having been replaced with thermally oxidized silicon nitride containing layer 18. This transition is clearly shown in upon comparison of Figs. 2 and 3 in Shue, in which the silicon nitride layer 14 present in Fig. 2 is no longer present in Fig. 3, but is replaced with oxidized layer 18 in Fig. 3.

After forming the thermally oxidized silicon nitride containing layer 18, Shue then teaches forming silicon layer 22 on top of layer 18, to yield the structure shown in Fig. 4. Since the silicon nitride layer has been wholly consumed to become oxidized layer 18, Shue's disclosed method does not form an oxidation layer **<u>over</u>** the dielectric or silicon nitride layer as claimed in the present application.

3) *The Ma reference*

The Office Action relies on the Ma reference for its disclosure of a thickness range for dielectric layer 56. Regardless of the feature(s) disclosed in Ma relied upon in the Office Action, this combination of Shue and Ma is still insufficient to destroy patentability of Applicants' claimed invention, because Ma does not teach the features of the claimed invention lacking in Shue. In particular, Ma discloses forming a dielectric film layer 56 by preparing a precursor made from 1) a metal selected from zirconium and hafnium; 2) oxygen; and 3) a trivalent metal selected from aluminum, scandium, and lanthanum. (Ma, col. 6, lns. 58-64; col. 7, lns. 44-60). This film 56 is then annealed. (Ma, col. 7, lns. 28-34, 61-65). After annealing, gate electrode 58 is formed on the annealed layer 56, as shown in Fig. 13 and discussed at column 7, lines 35-40. In view of this structure, it is clear that Ma, like Shue, does not disclose forming an oxidation layer over a dielectric layer or silicon nitride layer as recited in Applicants' independent claims 1 and 40.

B) <u>Neither Shue nor Ma teaches or suggests forming an oxidation layer by contacting a dielectric layer or silicon nitride layer with hydrogen, oxygen and nitrous oxide gases as recited in independent claims 1 and 40.</u>

1) *The claimed invention*

Claim 1 in the present application recites "contacting [the dielectric] layer with hydrogen, oxygen and nitrous oxide gases so as to form an oxidation layer over [the dielectric] layer." Similarly, independent claim 40 recites "contacting [the] silicon nitride layer with hydrogen, oxygen and nitrous oxide gases so as to form an oxidation layer over [the] silicon nitride layer."

In the present invention, the claimed combination of gases, i.e. hydrogen, oxygen and nitrous oxide gases, is critical in the formation of the oxidation layer. As discussed throughout Applicants' specification and demonstrated in the experimental data provided in Tables 1 and 2 on pages 13-14 thereof, significant and unexpected reduction in capacitor leakage current is observed when the capacitor dielectric is oxidized with

hydrogen, oxygen and nitrous oxide gases as compared with the leakage current obtained when the dielectric layer in the capacitor was oxidized by other gases or gas combinations. Specifically, the samples of Group I in Tables 1 and 2 were oxidized using only hydrogen and oxygen gases, while the samples in Groups 2-4 were oxidized using a mixture of hydrogen, oxygen, and nitrous oxide. Table 2 shows that the leakage current through the dielectric layers of the samples of Groups 2-4 were greatly reduced from the leakage current through the dielectric layers of the samples of Group 1. For example, for the samples having a dielectric layer thickness of 47 Angstroms, the amount of leakage current obtained upon applying –1.6 V to the capacitors of Groups 1-4 are –4.46E-08 A/cm$^2$, -2.05E-08 A/cm$^2$, -1.88E-08 A/cm$^2$, and –1.64E-08 A/cm$^2$, respectively. This data indicates that the leakage current observed in the samples of Groups 2-4 equate to 46%, 42%, and 37%, respectively, of the leakage current observed in the samples of Group 1. As mentioned on page 10, lines 16-24 in the specification, it is not known exactly why the use of the claimed mixture produces such superior results, but a marked improvement in leakage current suppression does clearly occur.

2) *The Shue reference*

Column 7, lines 18-61 in Shue describes the process of converting the silicon nitride containing layer 14 to the thermally oxidized silicon nitride layer 18. While Shue may be considered to disclose oxidizing the silicon nitride containing layer 14 with an admixture of oxygen and nitrous oxide gases as one of a myriad of possible oxidizing gas combinations disclosed in column 7, lines 49-55, Shue never mentions the use of hydrogen gas anywhere in the reference, much less for forming an oxidation layer over a dielectric layer in combination with the oxygen and nitrous oxide gases, as recited in Applicants' claims.

Despite Shue's failure to mention the use of hydrogen gas, lines 1-2 of page 3 in the Office Action appears to imply that claims 11-14 in Shue teaches the use of hydrogen gas in an oxidation process. A careful review of the reference, however, reveals that this is

an incorrect interpretation of Shue's method. Claim 11 in Shue recites "wherein . . . the reducing material is a hydrogen containing reducing material." A "hydrogen containing material" is not *per se* a teaching of hydrogen gas. Even assuming *arguendo* that this is a teaching of hydrogen gas, Shue does not teach using the hydrogen gas for oxidizing the dielectric or silicon nitride layer, as becomes apparent upon understanding the context in which the hydrogen gas is discussed in Shue. Specifically, claim 11 in Shue depends from claim 7. The "reducing material" recited in claim 11 refers to the reducing material which is specifically excluded from the "first thermal annealing method" recited in claim 7 (col. 12, lns. 17-18) (reciting that the annealing process is performed in a nitrogen containing atmosphere, "in the absence of . . . a reducing material."). This annealing method corresponds with the formation of the silicon nitride layer 14 by partially consuming the silicon layer 12 as discussed in column 6, lines 39-62 in Shue, and as mentioned above. Thus, Shue teaches that hydrogen gas is excluded during the formation of the silicon nitride layer. This is certainly not a teaching that hydrogen gas is used in combination with oxygen and nitrous oxide gases to form an oxidation layer on a dielectric layer, as claimed in the present application.

3) *The Ma reference*

Ma also does not teach oxidizing a dielectric layer with the claimed combination of oxygen, hydrogen and nitrous oxide gases to form an oxidation layer thereon. Column 6, lines 28-30 in Ma discloses that the dielectric film is annealed in inert and/or oxidizing gases. $O_2$ and NO are listed among the oxidizing gases which may be used, but not $H_2$. It is noted that Ma discloses $N_2$:$H_2$ forming gas as an annealing gas. $N_2$:$H_2$ forming gas is a well known annealing gas, and is different from $H_2$ gas alone. Thus, Ma, like Shue, is silent with respect to the use of hydrogen gas in combination with oxygen and nitrous oxide gases to form an oxidation layer on a dielectric layer.

4) *No motivation in Shue or Ma to use claimed combination of gases*

Neither Shue nor Ma, whether considered alone or in combination, specifically teaches or suggests using exactly the claimed mixture of hydrogen, oxygen, and nitrous oxide gases to oxidize a dielectric layer of a capacitor. One of ordinary skill in the art would not have been influenced by Shue or Ma to use the claimed mixture of gases to oxidize a dielectric layer, because neither of the references recognizes the unexpectedly superior results of using the claimed mixture.

Although one of ordinary skill in the art may be capable of adding hydrogen gas to oxygen gas and nitrous oxide gas simply because these gases are all known, it is inappropriate to conclude that it would have been obvious to modify the cited references in accordance with Applicants' claimed invention unless the references provide motivation for specifically selecting the exact combination of gases recited in Applicants' claims to form an oxidation layer on a dielectric or silicon nitride layer in a capacitor. The requirement for demonstrating motivation in the references when rejecting a claim under obviousness is well-established in case law. In <u>In re Mills</u>, the Federal Circuit held that "[w]hile [the prior art] apparatus may be capable of being modified to run the way [applicant's] apparatus is claimed, there must be a suggestion or motivation in the reference to do so." 916 F.2d 680, 682, 16 U.S.P.Q.2d 1430, 1432 (1990). Similarly, in <u>Ex Parte Levengood</u>, the Board of Appeals reversed a rejection, stating that "[a]t best, the examiner's comments regarding obviousness amount to an assertion that one of ordinary skill in the relevant art would have been able to arrive at the appellant's invention because he had the necessary skills to carry out the requisite process steps. This is an inappropriate standard for obviousness." 28 U.S.P.Q.2d 1300, 1301 (Bd. Pat. App. Int. 1993). *See also* <u>In re Bond</u>, 910 F.2d 831, 834, 15 U.S.P.Q.2d 1566, 1568 (Fed. Cir. 1990); MPEP 2143.01.

Even if all of the elements of a claimed combination are indistinguishably disclosed within a list in a reference, the Federal Circuit has held that such nonspecific disclosure of the claimed elements embedded in a list is insufficient to render the claimed combination

obvious. In <u>In re Rouffet</u>, the Federal Circuit overturned an obviousness rejection on the basis that although all the elements of the claimed invention were taught in the cited references, there was no motivation provided in the references to modify the prior art to arrive at the claimed invention. 149 F.3d 1350, 47 U.S.P.Q.2d 1453 (1998). In the present application, neither Shue nor Ma even teaches the use of hydrogen gas in an oxidation process on a dielectric or silicon nitride layer, much less provides motivation for selecting the combination of hydrogen, oxygen and nitrous oxide gases from among the many different combinations of gases known to those of one of ordinary skill in the art.

Unless the references themselves provide motivation to modify a prior art invention in the manner claimed by Applicants, any conclusion that Applicants' claimed invention is obvious over Shue and/or Ma constitutes improper hindsight reconstruction based on knowledge gleaned from Applicants' own specification, and as such, is impermissible. *See, e.g.*, <u>In re Gorman</u>, 18 U.S.P.Q.2d 1885, 1888 (Fed. Cir. 1991) (stating that "[i]t is impermissible . . . [to use] the applicant's structure as a template and [select] elements from references to fill the gaps."). *See also* MPEP 2141 (instructing that "[w]hen applying 35 U.S.C. 103, the following tenets of patent law must be adhered to: . . . (C) The references must be viewed without the benefit of impermissible hindsight vision afforded by the claimed invention.")

In addition to the reasons explained above, the rejection that the claimed invention is obvious over Shue and Ma is also improper because it fails to consider the unexpectedly reduced leakage current in a capacitor fabricated with an oxidation layer formed using the hydrogen, oxygen and nitrous oxide gases as recited in Applicants' claims, in comparison with the leakage current through capacitors having oxidation layers formed with other gas mixtures. Experimental data demonstrating the unusual improvement obtained with the claimed invention is set forth in the specification, as discussed above. MPEP 2141 requires that "[o]bjective evidence or secondary consideration such as unexpected results . . . When evidence of any of these secondary considerations is submitted, the examiner <u>must</u> evaluate the evidence." (emphasis added). Meanwhile, neither Shue nor Ma even

acknowledges that leakage current is a problem with oxidation layers in capacitors, and consequently never addresses the desirability to decrease leakage current through an oxidation layer in a capacitor.

As demonstrated above, Shue and Ma, either alone or in combination, fail to teach or suggest forming an oxidation layer over a dielectric or silicon nitride layer, or using a combination of hydrogen, oxygen and nitrous oxide to form an oxidation layer in a capacitor as recited in Applicants' independent claim 1 and 40. Moreover, the Office Action fails to appreciate the unexpectedly reduced leakage current obtained in the capacitors formed by the claimed invention. Further in this regard, both Shue and Ma fail to disclose any desirability to reduce leakage current as unexpectedly obtained by the claimed invention. For at least each of these reasons, Applicants respectfully submit that the invention recited in claims 1 and 40 is not rendered obvious by the teachings of these references.

Claims 2-39 and 41-59 each depend ultimately from independent claims 1 and 40, respectively. Each of these claims is patentably distinguishable over Shue and Ma by virtue of their ultimate dependencies on claims 1 and 40 for the reasons presented above. However, each claim recites additional subject matter which, in combination with the subject matter recited in the corresponding independent claim and any intervening claims, are not taught or suggested in Shue or Ma, and therefore, provide additional bases of patentability over the cited references.

In view of the foregoing, each of the presently pending claims in this application is believed to be in immediate condition for allowance. Accordingly, the Examiner is respectfully requested to withdraw the obviousness rejection over Shue and Ma and to pass this application to issue.

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Respectfully submitted,

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